Information for Successful Interaction with Autonomous Systems

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with thanks to the HCAAST project team:

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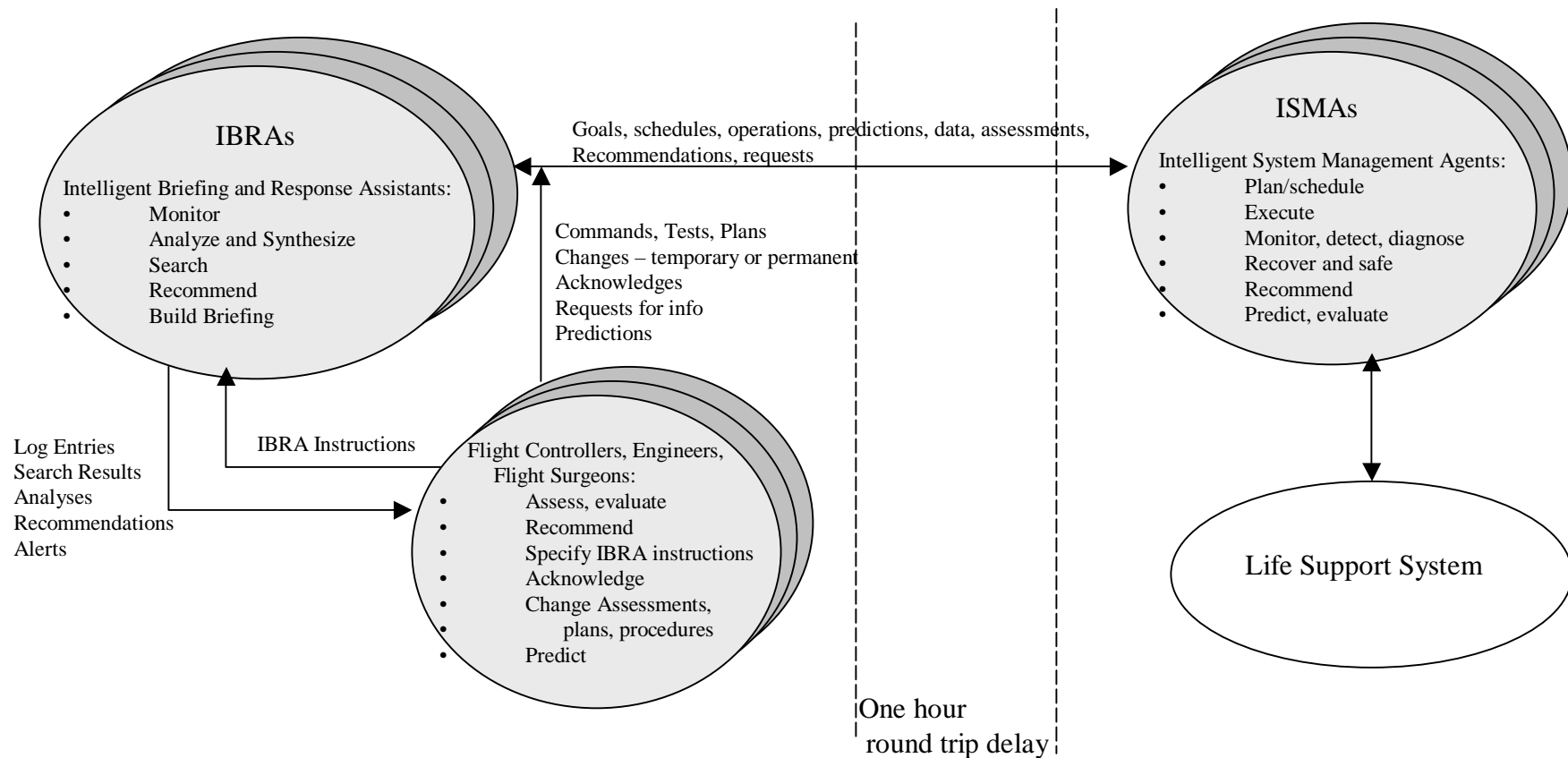
NASA Johnson Space Center

Challenges for Autonomous Agents

- Autonomous remote processing plants with limited communication
  - One hour round-trip delays and low bandwidth
- Shifting between autonomy and teamwork to handle inevitable unexpected problems
- Communication among heterogeneous agents managing multiple complex systems
- Loose coordination for flexible multitasking teams
  - Mixed initiative interaction and coordination
  - Updates and orientation rather than continuous monitoring
  - Loose "commanding" predominates
    - Change knowledge, beliefs, goals and intentions

Earth

Planetary Base

IBRAs

Intelligent Briefing and Response Assistants:
- Monitor
- Analyze and Synthesize
- Search
- Recommend
- Build Briefing

Goals, schedules, operations, predictions, data, assessments,
Recommendations, requests

ISMAs

Intelligent System Management Agents:
- Plan/schedule
- Execute
- Monitor, detect, diagnose
- Recover and safe
- Recommend
- Predict, evaluate

Commands, Tests, Plans
Changes – temporary or permanent
Acknowledges
Requests for info
Predictions

Log Entries
Search Results
Analyses
Recommendations
Alerts

IBRA Instructions

Flight Controllers, Engineers,
Flight Surgeons:
- Assess, evaluate
- Recommend
- Specify IBRA instructions
- Acknowledge
- Change Assessments,
      plans, procedures
- Predict

Life Support System

One hour
round trip delay

# Mission Operations Agents, Activities and Information Flows

Cooperating Intelligent Agents

- Autonomous System Management Agents
  - Communicate to coordinate, get and give help and enable common ground (manifest or talk about)
    - Execute, monitor, safe and recover
    - Detect, diagnose, assess and predict
    - Construct and evaluate plans, schedules and actions

- Helper Agents – specialists and generalists
  - E.g., Intelligent Briefing and Response Assistants, to manage information from systems, system management agents, and human team members
    - Monitor, make console log entries
    - Analyze data patterns
    - Search
    - Build and organize briefings and notices

Roles and Functions in Anomaly Response

Vehicle
- Recognize anomaly
- Safe system
- Record anomaly info
- Send anomaly info to ground for detailed analysis
- Initiate diagnostic testing

telemetry →

Anomaly info →

Proposed actions →
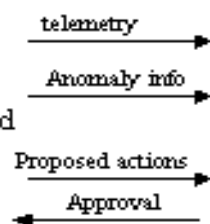
← *Approval*

Multi-Discipline Officers
- Recognize, confirm, and log anomaly
- Assess importance and urgency
- Notify Discipline Specialist
- Take immediate action if necessary (short term responses, approvals)
- Collect info for discipline specialist
- Notify flight director

notification

Bundled situation report

Discipline Specialists
- Receive notification of anomalies
- Based on urgency and importance, decide when to do detailed review and analysis
- Review situation in detail
- Review actions taken
- Look at relevant documentation
- Consider impacts to upcoming activities
- Consult colleagues, engineering, flight director
- Complete IFI and other documentation of incident
- Formulate and record initial assessments
- Perform detailed analysis and make report
- Consider asking for full anomaly response team, consult flight director
- Report to flight director
- Decide actions to be taken, consult flight director
- Record decision and rationale
- Send actions as plan inputs

- Receive and apply changes to MDO operations sent from discipline specialist

Changes to operations

- Receive plan inputs
- Incorporate inputs into daily plan
- Execute plan

← *Plan inputs (diagnostic, recovery)*

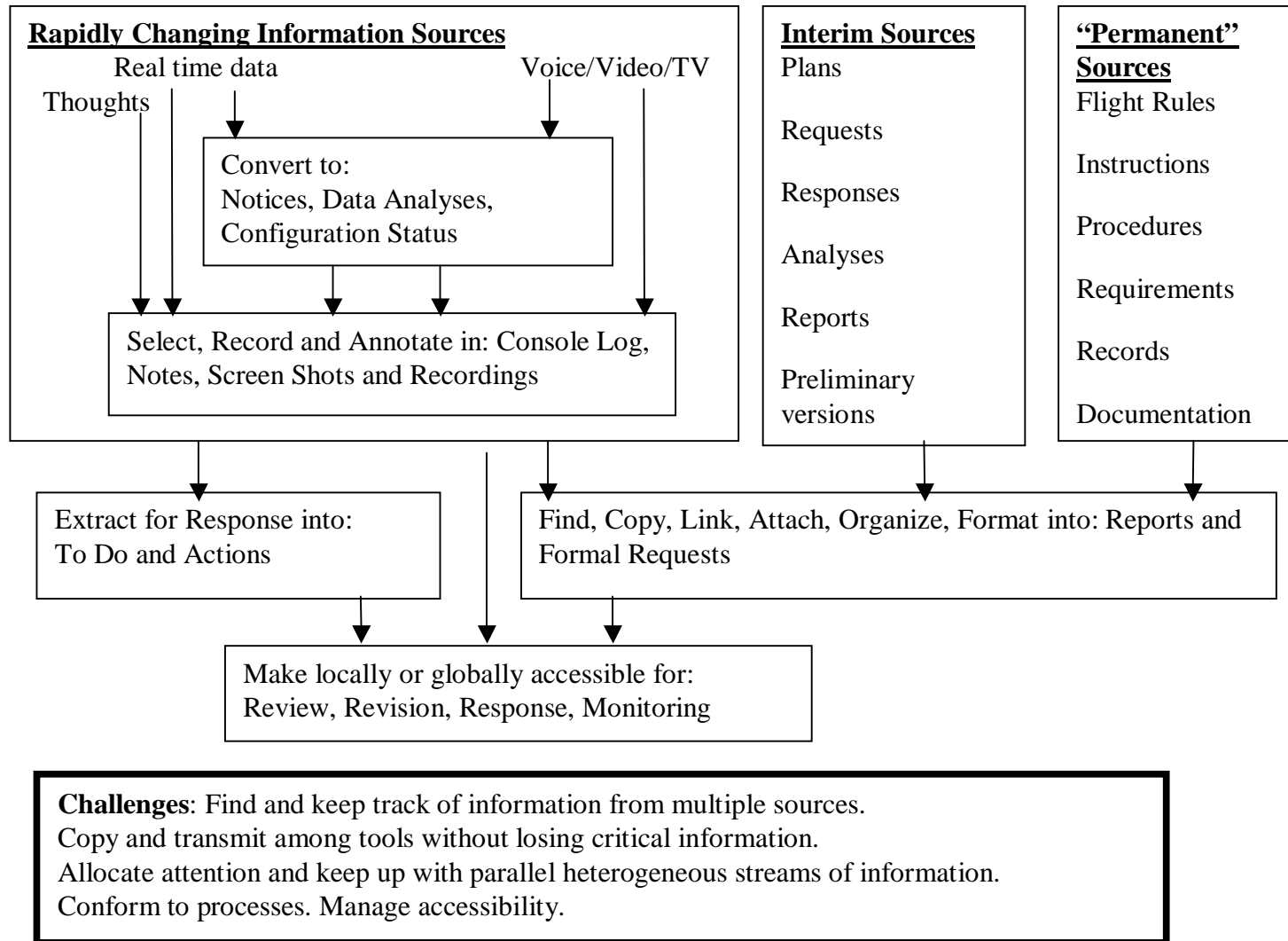**Intelligent Systems Management Agents (ISMAs) and Crew**

Intelligent Briefing and Response Assistants (IBRAs) and Mission Support

Information Handling in Control Center Shifts

Rapidly Changing Information Sources

Real time data   Voice/Video/TV

Thoughts

Convert to:
Notices, Data Analyses,
Configuration Status

Select, Record and Annotate in: Console Log,
Notes, Screen Shots and Recordings

Interim Sources
Plans

Requests

Responses

Analyses

Reports

Preliminary
versions

"Permanent"
Sources
Flight Rules

Instructions

Procedures

Requirements

Records

Documentation

Extract for Response into:
To Do and Actions

Find, Copy, Link, Attach, Organize, Format into: Reports and
Formal Requests

Make locally or globally accessible for:
Review, Revision, Response, Monitoring

Challenges: Find and keep track of information from multiple sources.
Copy and transmit among tools without losing critical information.
Allocate attention and keep up with parallel heterogeneous streams of information.
Conform to processes. Manage accessibility.

IBRA Role and Infrastructure

- Intelligent Briefing and Response Assistants manage information by executing Act-Whenever requests
  - React to triggers, simple or complex
    - Monitor data stream and scan database
  - React by using tools to process and distribute information
    - Use same tools as the human agents on mission support team
- Actions: automated information handling for situational awareness and anomaly response
  - Collect, analyze and organize data and ISMA information and reference materials associated with an event
  - Enter data and information into **shift logs and notes**
  - Organize and link data, information, log entries and notes into **notices and reports**
  - Select, collect, link and organize reports and filtered logs in shareable issue-focused **workspaces**

IBRA Uses Information Handling Tools
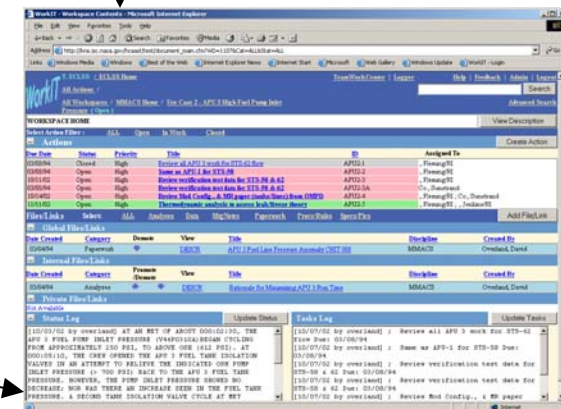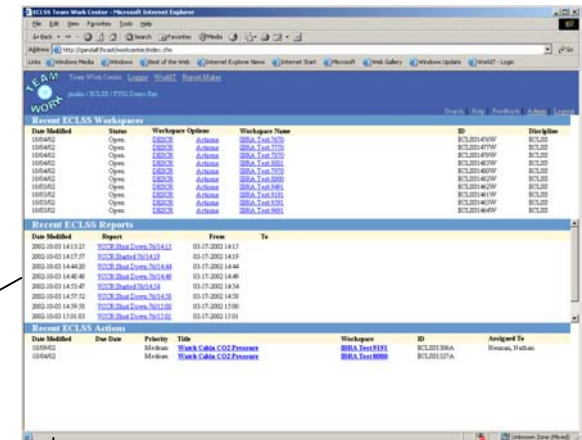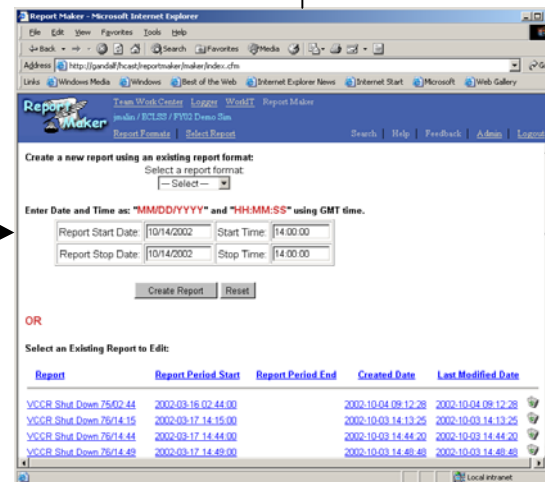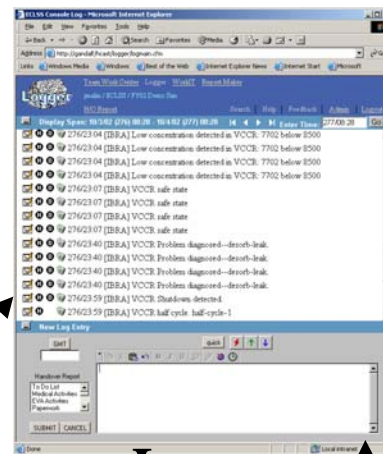
Logger

Team Work Center

IBRA Agent

Report Maker

WorkIT Workspaces

Interacting with System Management Agents

- ## Assessment: monitoring and reviewing
  - Peripheral/loose (abstract awareness info) or close/tight (synchronized)
  - One or more managed systems (e.g., Life support systems)
  - Systems with and without autonomous system management agents
  - One or more supervisors/collaborators, including shift work and distributed or shared supervisory roles

- ## Intervention and operation
  - Request services: information, actions and cognition (e.g., replanning)
  - Direct: command, activate and configure managed system and agent
  - Correct: inform or change underlying knowledge

- ## Understanding for shifting team relationships (supervisor, collaborator…)
  - Understanding, awareness, detection, diagnosis and prediction
    - States, events and actions and their causes or influences
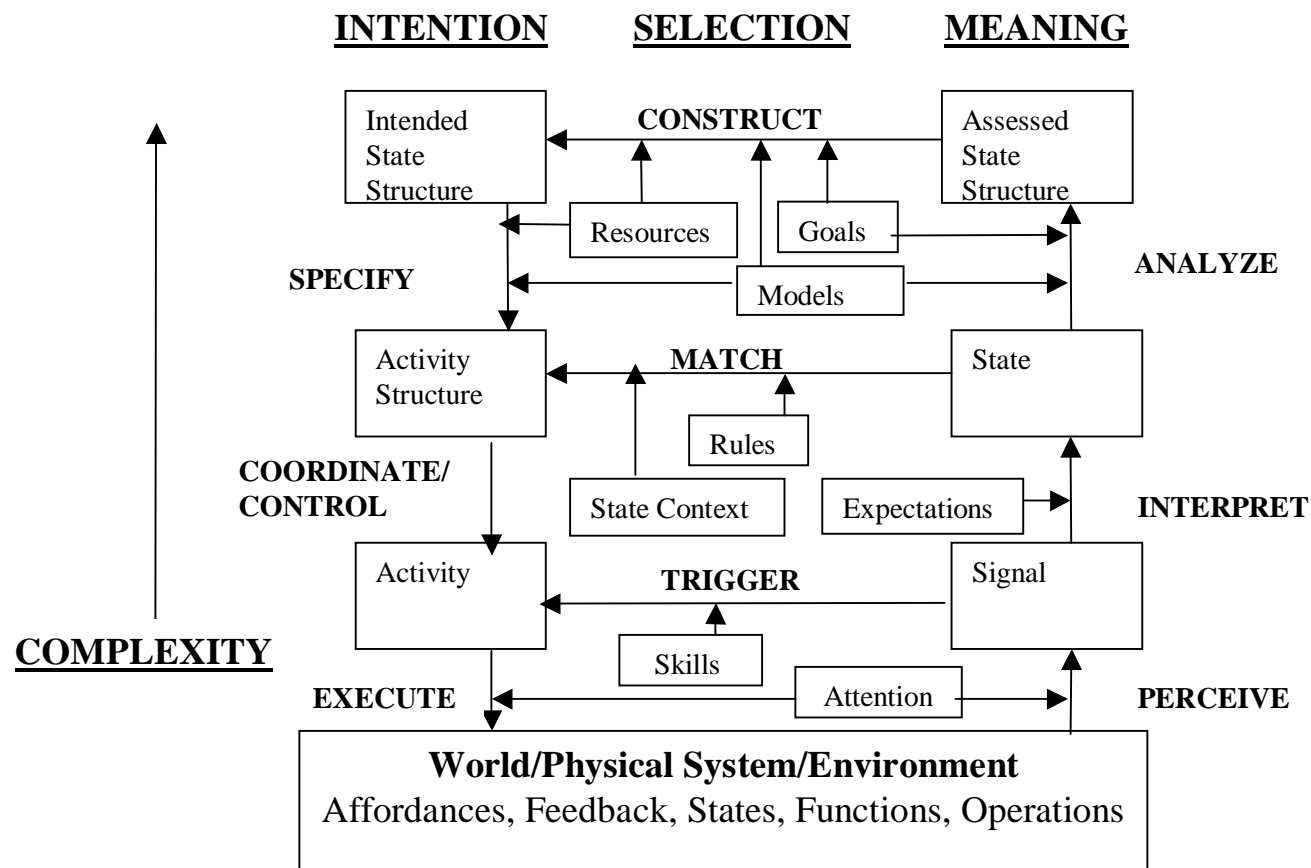
Support for Human Interaction

- Agents that support shifting among types of interaction, to handle agent errors and anomalies
  - From assessment to direction to correction to substitution
  - Understanding and awareness
- Agents (and helper agents) that support human intervention and collaboration tasks
  - Formulation of the service request, information change or command
    - Offer knowledge or methods to change or command
  - Evaluation, testing and review of implications
    - Prediction, simulation…
  - Coordination and execution of the intervention
    - Designed for change and flexibility in plans and procedures

Orienting for Agent Intervention

- Knowledge for shifting from awareness to supervision and intervention – interpret and expect
  - cf. Norman, Brooks, Rasmussen
  - What, who and when: Events, agents and actions
  - How: Layers of information processing methods
    - Meaning: Perception, interpretation and evaluation
      - Effects of attention, memory and expectation
    - Intention: Triggering, selection, construction and specification
      - Effects of interpretation, resources and goals
    - Activity: Construction, coordination and execution
  - Why: Layers of underlying knowledge
    - Skills, rules, expectations, models and goals …
    - Increasing complexity and decreasing specialization

Agent Cognition and Complexity:
What you may need to <u>know</u> to intervene and What you may need to <u>communicate</u> about

INTENTION   **SELECTION**   **MEANING**

Intended State Structure → **CONSTRUCT** → Assessed State Structure

Resources   Goals

SPECIFY   Models   **ANALYZE**

Activity Structure ← **MATCH** ← State

Rules

COORDINATE/ CONTROL   State Context   Expectations   **INTERPRET**

Activity ← **TRIGGER** ← Signal

COMPLEXITY   Skills

EXECUTE   Attention   **PERCEIVE**

World/Physical System/Environment
Affordances, Feedback, States, Functions, Operations

Supportive Autonomous System Management Agents

- Measures of success are needed for phases and tasks in supervising and coordinating with agents that manage operations of systems (low effort, low error)
  - Understanding layers of events, cognition and knowledge
  - Formulating and evaluating levels of proposed interventions and collaborations
  - Coordinating and executing levels of interventions
- Develop interaction scenarios to benchmark support by groups of agents made up of autonomous agents and their helper agents